AIR FORCE HUMAN RESOURCES LABORATORY

AFHRL (FT)-TRM-5

EVALUATION OF THE SIMULATOR FOR AIR-TO-AIR COMBAT DISPLAY BY AFHRL-FT

by

Robert R. Woodruff
Captain Richard C. Oliver

FLYING TRAINING DIVISION
Williams Air Force Base, Arizona

March 1971

AIR FORCE SYSTEMS COMMAND

BROOKS AIR FORCE BASE, TEXAS

UNCLASSIFIED

Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY *(Corporate author)*

Flying Training Division (FT)
Air Force Human Resources Laboratory (AFHRL)
Williams AFB, AZ 85224

2a. REPORT SECURITY CLASSIFICATION

U

2b. GROUP

3. REPORT TITLE

EVALUATION OF THE SIMULATOR FOR AIR-TO-AIR COMBAT DISPLAY BY AFHRL-FT

4. DESCRIPTIVE NOTES *(Type of report and inclusive dates)*

5. AUTHOR(S) *(First name, middle initial, last name)*

Woodruff, Robert R. and Oliver, Richard C., Captain

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
March 1971	17	0

8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S)
b. PROJECT NO. 686F	AFHRL (FT)-TRM-5
c.	9b. OTHER REPORT NO(S) *(Any other numbers that may be assigned this report)*
d.	

10. DISTRIBUTION STATEMENT

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	x2226 AFHRL(FT) Lt Col David O. Andersen Chief, Flying Training Division

13. ABSTRACT

This memorandum describes the procedure used to evaluate the psychological acceptability of a visual display technology which will be utilized by the Advanced Simulation in Undergraduate Pilot Training (ASUPT) research simulator. Results of the evaluation are included (U).

DD FORM 1 NOV 65 1473

UNCLASSIFIED

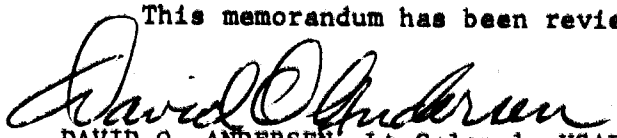
Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Simulation						
Undergraduate Pilot						
Visual Display Technology						
Training Research						

FORWARD

The data reported in this memorandum are the results of research conducted at the Flying Training Division. The research was conducted under Project 686F, Innovations in Training and Education, Unit A, Advanced Simulation in Undergraduate Pilot Training.

This memorandum has been reviewed and is approved.



DAVID O. ANDERSEN, Lt Colonel, USAF
Chief, Flying Training Division

EVALUATION OF THE SIMULATOR FOR AIR-TO-AIR COMBAT DISPLAY BY AFHRL-FT

Prepared by Mr Robert R. Woodruff and Captain Richard C. Oliver

The role of simulation in Undergraduate Pilot Training (UPT) is an area essentially untouched by training research. Nevertheless, basic principles of human learning and skill acquisition suggest that simulators could be very effectively used to train novice pilots. In recognition of this, the U.S. Air Force has established a formal investigation. This is "Advanced Simulation in Undergraduate Pilot Training" (ASUPT), Unit A of the Advanced Development Program, "Innovations in Training and Education."

In support of this project the Air Force Human Resources Laboratory will construct a large flight simulation research facility at an undergraduate pilot training base. The base chosen is Williams AFB, AZ. Contracts are being awarded in 1971 and it is expected that the facility will become operational in late 1973. The purpose of the facility is to study design features, and to develop methods and techniques for maximum effective use of flight simulators in Undergraduate Pilot Training programs.

Initially the facility's research equipment will consist of two T-37B simulators. Each of these will incorporate a synergistic-six-degree-of-freedom motion system and a wide angle in-line infinity optical visual display which will display computer-generated imagery. A sophisticated computer complex will drive the cockpit, the motion system, the display and will provide a variety of advanced instructional provisions as well as on-line data analysis capability.

It is planned that the visual display will consist of seven contiguous facets of a dodecahedron. The student pilot's eye position will be at the center of this space. Each of these facets will consist of an external cathode ray tube and optics necessary to present the CRT image at infinity inside the dodecahedron. The seven facets will be arranged so that the student pilot will see a scene of 240° horizontally by +100°, -40° vertically.

It is intended that the computer, motion system, image generator and display system will all utilize the most recent capabilities afforded by the state-of-the-art. The visual display presents the greatest risk. The in-line optical technique is relatively new technology and manufacturing involves large size complex optics.

The Aeronautical Systems Division (ASD) has been pursuing the development of an in-line infinity optical display exactly like the one proposed for the AFHRL facility except that it is only 0.8 times as large. It is

The assistance of 1st Lt Frank E. Bell, III, Mr James Basinger, and Mr Don Gum in carrying out this project was appreciated.

being developed for an air-to-air combat simulator (SAAC) which will simulate the performance of two fighter aircraft. AFHRL has been directed to watch this development carefully to be assured that the display is both engineeringly feasible and psychologically acceptable.

Successful fabrication of the complete SAAC display will be considered to indicate engineering feasibility even though the AFHRL display will be larger. No better test is available. During January 1971, a prototype of the ASD display was set up and operating at Wright-Patterson AFB (WPAFB). This prototype included only two of the seven projected facets, but it was considered that AFHRL should take this early opportunity to evaluate the display's psychological acceptability. This was done 26 January 1971.

The display at WPAFB differed in several ways besides the number of facets, from the display which AFHRL will eventually purchase. These differences are listed in Atch 1. Since the SAAC display being demonstrated did differ to such an extent from the one which will be purchased for ASUPT, it was not possible to decide absolutely by this evaluation that the display was suitable for ASUPT. Rather than this, the intent of the 26 January evaluation was merely to determine that the equipment as it existed did not indicate potential psychologically proscriptive difficulties. In order to do this it was important to insure that only psychological acceptability was evaluated; not hardware. Persons who were to evaluate the display had to be prepared to distinguish between the psychological effect of the display technology used and the adequacy of the actual hardware before them.

There were at least four characteristics of the technology which were of particular concern from a psychological point of view. These were as follows: (1) joints between the dodecahedron facets are visible as black bands when the viewer's eyes are moved from a central position; (2) the in-line infinity optics involve repeated reflection of polarized images to produce the desired image. Unfortunately the polarizers and other optical elements are not one hundred percent efficient, and unwanted images, called ghosts, are dimly visible in the display; (3) each facet includes several glass surfaces which may reflect cockpit lights, and (4) the images are wide field-of-view presented at thirty frames per second. The possibility of perpheral flicker was a concern.

Care was taken to appropriately prepare the psychological set of the evaluators. Immediately prior to their participation they were briefed on the nature of their task. Differences between the hardware they would see and the ASUPT display concept were pointed out (Appendix I); they were shown a movie of dynamic CIG imagery, and they were given an orientation statement (Appendix II).

There were nine evaluators. Each evaluator has been assigned a number. Appendix V is a list by number of the evaluators' organizations and experience. This list may be compared with their comments which are also numbered. They sat in the display one at a time and were taken through a structured evaluation procedure (Appendix III) by intercom. The evaluators unanimously agreed that faceted, in-line infinity optical technology would be satisfactory for the purpose of ASUPT. Their comments are attached (Appendix IV).

Based on the favorable results of this evaluation, AFHRL is proceeding to purchase a larger version of the SAAC type display for ASUPT. It is necessary to begin now, to accommodate the lead times required. However, the display hardware which was evaluated only approximately represented the ASUPT display. It was necessary in effect for evaluators to imagine the ASUPT display based on what they saw, and to project features of the technology which might contribute to psychological unacceptability from the SAAC prototype to the future ASUPT situation. While as was stated, it is accepted that this procedure could reveal proscriptive features, it could not provide unqualified endorsement of the display. For this reason AFHRL will closely follow the continued development of the SAAC display which is expected to commence again late in 1971. As more complete displays, whether SAAC or ASUPT become available, they will be subject to close examination. Design modification, or even program redirection will be considered in the future, if necessary, to protect the ability of ASUPT to fulfill its mission.

APPENDIX I. DIFFERENCES BETWEEN ASUPT AND TODAY'S DEMONSTRATION

ITEM	DEMONSTRATION	ASUPT
Number of Scan Lines	573	1023
Horizontal Resolution	600	1023
Distance to Display (Inches)	29	37
Viewing Brightness	2 f.l.	6 f.l.
Number of Channels	2	7
Raster	Partial	Full
Image Generator	TV Cameras	CIG
Dynamics	None	Full
Tasks to be Performed	None	Flying

APPENDIX II. ORIENTATION

The visual display technology you will be examining is proposed for use in the ASUPT research system. The scenes are displayed on cathode ray tubes and viewed through optical elements which collimate the light rays (producing images at infinity) and permit two or more channels to be mosaiced (providing a continuous field of view). During today's evaluation a TV camera will be viewing a variety of photographs to drive the displays.

Since this display technology produces pictures which are black and white and raster-scanned, they do not duplicate the real world completely, regardless of their source. A visual simulation system which provides a less-than-perfect representation of the real world can nonetheless be effective, and the key question to be answered is "Will this type of display be acceptable for flight?" If the answer is yes, ASUPT will be an effective training research device.

Please rely on your pertinent experience to judge the utility of such a display for flight simulation. Do not rate the display down simply because it fails to represent reality accurately. Remember that it can still have significant training value. Do rate it down, however, if you believe that the quality of the images is unacceptable.

APPENDIX III. EVALUATION PROCEDURE

S enters display and is seated. The E then reads the following to him over the intercom.

"Can you hear me? Please move your head position until you have the best picture as if you had an adjustable seat. The seat should be in the full forward position. When you are finished in here we will give you a questionnaire. The questions are designed to get at your impressions rather than your memory, but please remember the characteristics which particularly interest you. We will also ask you for comments of this nature. Please keep in mind that we hope the ASUPT will eventually have seven display facets similar to the two you see now. It will have a field of view of ±120° horizontally (total 240°) by 100° up, 40° down (total 140°) vertically. Also remember that the seven ASUPT facets will display integrated CIG dynamic images like the film you have seen. The images you will see now are televised drawings and photographs, and they will be shown primarily on one facet. Finally the raster on this display is 500 lines. The one ASUPT uses will be 1000 lines, providing twice the resolution.

You will be shown several pictures, some on one facet, some on the other, some on both. Please perform the following exercises as you view each picture:

First look at a point on the left side of the picture. Now shift your gaze and look at a point on the right side. Notice whether you were able to focus on the second point as quickly as you would if the situation was real. Alternate starting side.

2nd - look at the panel below the display. Then shift your gaze to a point in the display. Were you able to focus as rapidly as normal?

3rd - move your head around as it might move in normal and in aerobatic flight. Does the picture remain stable, undistorted and in focus?

Do you have any questions? The first scene will demonstrate edge matching on across facet coordination. First slowly scan from facet to facet across the joint - can you notice any discontinuity of image, if so, is it severe? If there is a shift in focus across the facet - will it be a distraction in a dynamic environment?

The pictures will be different views from a T-37B. The next sequence is three shots of the takeoff roll; stationary, accelerating, and rotation phase. The horizon references are visible and could be taught from a dynamic sequence (instructional orientation).

The next shot is from a T-37 on initial - at a single runway field. The apparent diving sensation is from the photo perspective.

Next are four pilot-eye views from final approach. The first view is on glide scope a half mile out. In the second view the aircraft is going slightly high on glide path (notice the runway perspective). On this one (third) the pilot is back on glide path and here (fourth) he is over the overrun. The next two pictures display CIG imagery.

This first one is a runway scene turning LH base to final. This is a CIG T-38 model to give an idea of detail analysis for formation training.

That concludes the sequencing of views. Consider whether this presentation will allow a pilot to determine and maintain aircraft attitude in contact conditions.

Now there are two more things we would like for you to examine before you leave the display. We want you to particularly notice some shortcomings of the display and decide whether they could adversely affect performance.

First, focus on the glass plates immediately in front of you on each of the facets. There are several of these; one behind the other. Try to see your reflection. Look for other reflections. Now I will turn on a simulated instrument light located so that you can see its reflection in the center facet. Reflections of this sort may occur in some facets of the ASUPT display. Are these reflections distracting and unreal enough to adversely affect performance?

Now keep looking at the glass plates. It is possible to see secondary images of the displayed image in the vicinity of these plates. Do you see them? Do you think that these unnatural images are distracting enough to adversely affect performance?

Any Questions? That's all we have for you to do. Thank you. Please get a questionnaire from Mr Woodruff as you leave.

APPENDIX IV. COMMENTS TO QUESTIONNAIRE

1. Do you believe that the technology of the SAAC display can be used to build a visual display which will satisfactorily simulate flight in the T-37 UPT environment?

Yes

No

Comments: (Please comment on ghosts, reflections, the tasks you did in the display and impressions you made notes about, etc.)

Favorable - Obvious problem of scan lines being too predominant but higher number of lines, motion of simulator and a dynamic visual display should cancel this out.

Noticed no ghosting. The window to the right seemed more harsh than the one directly in front. Head movement caused the merged image to separate. There were some very faint lines running from bottom left to upper right of the front window. These appeared as scratches or optical marks rather than TV distortion.

1. Do you believe that the technology of the SAAC display can be used to build a visual display which will satisfactorily simulate flight in the T-37 UPT environment?

Yes, Definitely

No

Comments: (Please comment on ghosts, reflections, the tasks you did in the display and impressions you made notes about, etc.)

The line separating the windows was a distraction even though the picture was not disjointed. I believe that in a dynamic situation it would not be a bother. Reflections were not a problem although they may be in a simulated night condition. Resolution was not too good but could still be used to some degree for training. The picture remained stationary with head movement.

I had no problem in placing myself in a flight situation. There was no problem in shifting focus from the instrument panel to the visual scene. I believe this system has great possibilities for both UPT students and for the air-to-air combat situation. Both the formation and landing sequence shots would be of some training value in their present state and have great promise in the intended state.

1. Do you believe that the technology of the SAAC display can be used to build a visual display which will satisfactorily simulate flight in the T-37 UPT environment?

Yes

No

Comments: (Please comment on ghosts, reflections, the tasks you did in the display and impressions you made notes about, etc.)

Ghosts are not apparent, even with head movement. It is difficult to extrapolate from a single light generation, just how distracting reflection would be. However, it would appear that if instruments are back lighted that this problem would be minimum. I believe a different color phosphor would improve contrast. Attention must be given to contrasting shades. Runway did not "jump out" as the primary element in these pictures as it would under "normal" conditions. Also, I would like to see an effort to evaluate the longer term exposure affects. That is, would the subject start picking the display apart? Could he overcome the tendency to become captivated by the scene, thus distracting from his tasks in the cockpit?

In general terms, I believe the visual display is satisfactory. However, the brightness level as observed in this display is unsatisfactory. The across facet picture definitely is an improvement over narrow field of view visual systems and appropriately places the pilot in the picture, which I believe is important.

1. Do you believe that the technology of the SAAC display can be used to build a visual display which will satisfactorily simulate flight in the T-37 UPT environment?

Yes

No

Comments: (Please comment on ghosts, reflections, the tasks you did in the display and impressions you made notes about, etc.)

The cross over between screens was better than I thought it would be. It will be interesting to see if it is distorted in the dynamic state. Reflections did not seem important and ghosts were not noticeable. However, these may be more obvious when the motion is added. Depth seemed to be a problem especially on the first of the series of pictures. The last picture of glide and flare seemed to be better. Detail and contrast was not as good as I expected.

#5

1. Do you believe that the technology of the SAAC display can be used to build a visual display which will satisfactorily simulate flight in the T-37 UPT environment?

Yes, Obviously

No

Comments: (Please comment on ghosts, reflections, the tasks you did in the display and impressions you made notes about, etc.)

Exceptional demonstration of the technology

Fairly hard to maintain real world balance and perspective - with full display vertigo might be a problem.

While there are some obvious brightness problems they appear solvable.

1. Do you believe that the technology of the SAAC display can be used to build a visual display which will satisfactorily simulate flight in the T-37 UPT environment?

Yes, Definitely

No

Comments: (Please comment on ghosts, reflections, the tasks you did in the display and impressions you made notes about, etc.)

Viewed two facets of a seven facet system and found them to provide the best visual perspective of any system I have ever encountered.

Rapid head movements or tilting the head did not affect the visual perception of the scene. The right facet, however, did produce an image of the CRT that was noticeable and distracting from the scene. Also, the grease pencil mark was very noticeable.

Detail of the aircraft and visual perspective regarding attitude was excellent for use in a training environment. The left edge of the right facet was easily observed when I moved around in the cockpit toward the right. This problem could possibly be minimized by lowering the seat height to the normal flying position. Edge matching was good with no obvious offset observed.

The horizontal scan lines were distracting initially, but I feel the effect would be dampened considerably in a dynamic visual environment.

Flashlight reflection no problem. Runway and inflight pictures provided a good perspective for training.

If the CIG can be developed and demonstrated in the visual simulation situation and if 1023 scan lines can be employed, ASUPT will have the best and most advanced state-of-the-art in visual simulation that is available.

Summary - I'm impressed.

#7

1. Do you believe that the technology of the SAAC display can be used to build a visual display which will satisfactorily simulate flight in the T-37 UPT environment?

Yes, Hope so

No

Comments: (Please comment on ghosts, reflections, the tasks you did in the display and impressions you made notes about, etc.)

No ghosts seen. Could see seams where mirrors meet. Static scenes looked realistic to me.

1. Do you believe that the technology of the SAAC display can be used to build a visual display which will satisfactorily simulate flight in the T-37 UPT environment?

Yes

No

Comments: (Please comment on ghosts, reflections, the tasks you did in the display and impressions you made notes about, etc.)

I noticed no serious ghosts or reflections. The resolution on the runway images was too low; however, color line drawings were used and probably were the cause. The CIG image had adequate resolution to present the necessary cues for formation flight. Image transfer across the facets was good. Perspective was off probably due to cockpit configuration. More scan lines are needed for the size image displayed. The 1023 will probably help considerably. Use of CIG with the SAAC display appears to be the best way to go in light of current visual technology.

#9

1. Do you believe that the technology of the SAAC display can be used to build a visual display which will satisfactorily simulate flight in the T-37 UPT environment?

Yes

No

Comments: (Please comment on ghosts, reflections, the tasks you did in the display and impressions you made notes about, etc.)

Ghosts were apparent but not too disconcerting. Since I got 3 images (2 in front, 1 on side) of single red light, it's possible that multiple instruments may prove a problem in night-lit cockpit.

The impression of being "in it" which was afforded by the wide field of view looks very promising. The joints were no problem, and color is not all that necessary. I am still concerned about detail, however, doubling the scan should help.

APPENDIX V. EVALUATOR KEY

	PRESENTLY ASSIGNED TO	FLIGHT EXPERIENCE	SIMULATOR EXPERIENCE
1.	AFHRL (FT)	2800 Hours 2000 - F-100 350 - UPT 450 - T-37 IP	T-37, T-33, F-100, GAM-83
2.	ATC, ASD (ATA)	4300 Hours 1100 - T-38 1200 - F-100 1100 - F-105 900 - C-47	None
3.	AFHRL (DO)	3500 Hours KC-97 - 1500 C-130 - 1000	Simulator experience includes REDIFON, Dalto, & Point Light Source Visual Systems
4.	AFSC (DLSL)	Non-Rated	None
5.	Hq ATC	2800 Hours 1000 - F-4 C-130, F-100, T-39	F-4 Simulator
6.	AFHRL (TR)	2200 Hours 768 - B-47E 844 - F-84F	F-111 simulator experience with visual display
7.	ASD (XRL)	Non-Rated	None
8.	USAF (DPTBD)	3000 Hours 1200 - T-37 F-86, T-38, A-1 T-33, T-39	747 - American Airlines
9.	ASD (ENCCP)	3000 Hours 1000 - C-47 307 - F-100	F-111A, C-135, 23/43 SMK